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Lurian Approach and Neuropsychology of Creativity

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Луриевский подход и нейропсихология творчества

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Background. Alexander Romanovich Luria (1902–1977) is a widely recognized authority, attributed with the birth and development of neuropsychology. Reading the list of Luria's publications makes us aware of the wide range of his interests: from the brain location of mental functions, through methods of rehabilitation and education, cognitive processing, issues of language, intellectual development or the impact of culture on human development, to intercultural research, and consequently to the neuropsychology of creativity. The purpose of this article is to show the link between Luria's approach and the neuropsychology of creativity, and to demonstrate that a process thinking, taking into account brain/mind state, offers a new way of conceptualizing different approaches to creativity, which can be a step toward their unification, bringing into relation the continuum of passage in nature to a transition from repetition to innovation to genius.

Objective. The aim of the present paper is to present the brain mechanisms of creativity. It discusses the neuropsychology of creativity as a subdiscipline developing on the borderline of: (1) medical neuroscience — using clinical and experimental neuroanatomical, neurophysiological, neurobiological, neurosurgical, neurological, neuropsychiatric and (2) social neuroscience — using social psychology and neuropsychology, social linguistics and neurocultural studies to help disabled people. Special focus is placed on the functioning of artists with various forms of brain damage. The relationships between brain damage and the quality of creation are also discussed. In addition, a review of opinions of various authors from around the world on the relationship of the healthy and the damaged brain with creativity is presented in the paper.

Case study. Described also are ways to avoid pitfalls in the interpretation of works of art taking into account Luria's syndrom analysis. While studying the neurological and neuropsychiatric basis of the creativity of people with various brain injuries, one should take into account the possibility of the co-occurrence of syndromes as well as the overlapping of symptoms. The paper presents a case history of the illness of an artist that illustrates the importance of performing a syndrome analysis based on the Lurian approach. It also indicates the significance of supporting any neuropsychological assessment with the use of neuromarkers to avoid arriving at a false diagnosis. In the case of the patient described neurophysiological studies (neuroimaging studies of the brain, quantitative electroencephalography (qEEG), event-related potentials (ERPs) and standardized Low Resolution Electromagnetic Tomography (sLORETA) have proved to be very useful in the confirmation of his neuropsychological and neuropsychiatric diagnosis.

Conclusions. The paper has presented data confirming the importance of Luria's approach in the development of the neuropsychology of creativity. It was also an attempt to explain why we create, and what goes on in our bodies and minds when we begin to explore creative possibilities. Art in all of its manifestations (visual art, music, literature, dance, theater, and more) is an important feature of human societies in both norm and pathology, and therefore deserves further study.

Keywords: *brain damage; brain injury; schizophrenia; neuromarker; art; self; culture***.**

Краткое введение. Александр Романович Лурия (1902–1977) является широко известным ученым, чье имя связано с зарождением и развитием нейропсихологии. Труды А. Р. Лурия свидетельствуют о широте его исследовательских интересов: от изучения умственных функций мозга до разработки методов реабилитации и обучения, когнитивной обработки, анализа проблем, связанных с языковым, интеллектуальным развитием, влиянием культуры на развитие человека, межкультурными исследованиями и нейропсихологией творчества. Цель данной статьи — описать связь между подходом А. Р. Лурия и нейропсихологией творчества и показать, что процессное мышление (с учетом состояния мозга/сознания) представляет собой новый способ концептуализации различных подходов к творчеству. Это может быть определенным шагом к их объединению (унификации).

Цель. В статье рассматривается нейропсихология творчества как дисциплина, которая развивается на стыке (1) медицинской нейробиологии, с использованием клинических и экспериментальных нейроанатомических, нейрофизиологических, нейробиологических, нейрохирургических, неврологических, нейропсихиатрических исследований, и (2) социальной нейронауки, с использованием данных социальной психологии и нейропсихологии, социальной лингвистики и нейрокультурных исследований, ее цель — помочь людям с ограниченными возможностями. Особое внимание уделяется деятельности художников с различными формами повреждения мозга. Нейропсихология творчества специализируется на изучении взаимосвязей между креативностью, функционированием мозга (структурами и связями) и индивидуальным самовыражением на основе социального и культурного сознания, а также

моделированием этих типов поведения по отношению к биологическим организмам, социальной и культурной среде. В статье прослеживается связь между повреждением мозга и качеством творчества. Подчеркивается, что язык и искусство являются коммуникативными системами, основанными на символическом и референциальном познании, при этом язык более чувствителен к повреждениям мозга, чем творческие функции. Представлен также обзор точек зрения различных исследователей относительно связи здорового и поврежденного мозга с творчеством.

Пример из практики. В статье описаны способы избежать трудностей при интерпретации произведений искусства с учетом синдромологического анализа Лурия. При изучении неврологических и психоневрологических основ творчества людей с различными повреждениями головного мозга следует учитывать возможность одновременного возникновения синдромов и совпадения симптомов. Представлена история болезни художника, которая иллюстрирует необходимость проведения синдромологического анализа, основанного на подходе Лурия. Это также указывает на важность проведения любой нейропсихологической оценки с использованием нейромаркеров, чтобы избежать ложного диагноза. В представленном случае нейрофизиологические исследования: нейровизуальные исследования головного мозга, количественная электроэнцефалография (qEEG), связанные с событиями потенциалы (ERP) и томография (sLORETA), оказались очень полезными для подтверждения нейропсихологической и нейропсихиатрической диагностики пациента.

Выводы. В статье представлены материалы, подтверждающие важность подхода А. Р. Лурия при изучении нейропсихологии творчества. Предпринята попытка объяснить, почему мы занимаемся творчеством, что происходит в наших телах и умах, когда мы начинаем применять творческие способности. Искусство во всех его проявлениях (изобразительное искусство, музыка, литература, танцы, театр и т. д.), как норма, так и патология, является важной особенностью человеческих обществ и поэтому заслуживает дальнейшего изучения.

Ключевые слова: *повреждение мозга; мозговая травма; шизофрения; нейромаркер; искусство; “я”; культура.*

Introduction

Alexander Romanovich Luria (1902–1977) is a widely recognized authority attributed with the birth and development of neuropsychology. This author often pointed to difficulties in understanding the relationship between the material body and the immaterial mind (Luria, 1976). The development of neuroscience now allows us to come closer to understanding the essence of this relationship (Glozman, 1999, 2013; Homskaya, 2001). Particular attention is paid here to the operation of the brain, with clinical neuroscience, and especially neurocultural studies, enabling one to go beyond brain processes and take into account not only the psychological and social, but also the cultural perspective (Pąchalska, Bednarek, & Kaczmarek, 2020).

Reading the list of Luria's publications makes us aware of his wide range of interests: from the brain location of mental functions, through methods of rehabilitation and education, cognitive processing, issues of language, intellectual development or the impact of culture on human development, to intercultural research (Luria, 1932, 1961, 1962, 1963, 1966, 1968, 1970, 1973, 1975, 1979, 1984; Neil, 2000). Particularly unusual at that time seems to be the broad view and ability to see new things that no one had paid attention to before. These include Luria's research on the cultural determinants of mental processes (Brown, 2020). This is one of the lesser known scientific areas of his interests, as indicated by Cole (1990) in the article entitled "Aleksandr Romanovich Luria: Cultural Psychologist". In an insightful presentation of his mentor's cultural interests, Cole points out the links between Luria's approach and the thought of Wilhelm Wundt (1874). This applies especially to the so-called psychology of peoples ("Völkerpsychologie"), created by Wundt. Luria, like Wundt, emphasized in his scientific activity that true knowledge of human nature is possible through the study of man's creations and the culture in which he lives, i. e., religion, language and myths. It is fascinating that after many years we are to discover the scientific romanticism of this great scholar, which actually brings closer an understanding of the essence of humanity (Sacks, 1990; Kaczmarek, 2001; Pąchalska & Kaczmarek, 2012).

It was Luria himself (1979) who taught us that man is a unique human being, with unique emotional, cognitive and social abilities that result from both biological, cognitive and cultural conditions. Man is the only organism living on Earth, capable of transforming the world thanks to specific forms of activity, such as science, inventions, literature, art (music, painting, theater, dance), sport and others (see also Geertz, 1962; Piechowski-Jozwiak & Bogousslavsky, 2013). Although his basic processes: that is attention, memory, perception, imagination and learning ability make him similar to other primates, he is distinguished by his unique ways of using these abilities, resulting in spectacular achievements. What allows man to develop an amazing mind and transmit culture is his social nature and social practice (Kaczmarek, 1999).

This vision of man and his capabilities is specific to Luria's clinical thinking. It contributes to a better understanding of the relationship between the brain and cognitive, emotional, adaptive and social behavior as well as with the cultural environment. It defines the self and world relationship, with particular emphasis on perception processes (how we see ourselves and the world, what we feel, how we think, what decisions we make) and actions (what and how we say and what and how we do) by modeling the brain organization. It is the creative potential of each person that connects them to the cultural life of the community and allows them to understand their contribution to its development (Pąchalska, 2019).

However, the development of each person's creative potential, as emphasized by Pąchalska, Bednarek, et al. (2020), depends on external conditions (social, communication, economic etc.) as well as on the functioning of the body (including the brain) and the mind of the person. Some of the body's dysfunctions do not necessarily have to affect creative possibilities, sometimes they can — on a compensation basis — affect their strengthening (as happens, for example, with the musical abilities of the blind). In most cases, however, the damage and dysfunction of body organs affect various types

of disturbances in creative processes. This happens especially in the case of brain damage (cf. Pąchalska, 2007, 2008, 2019).

The Neuropsychology of Creativity

The neuropsychology of creativity, until now, has been considered the science of the relationship between brain and creativity. This can be explained by the fact that initially the neuropsychology of creativity was developed in close connection with neurology and neurosurgery. This is evidenced by the classic case reports of artists in the subject literature (Leischner & Pendzialek-Langer, 1974; Pąchalska, 1977, 1999, 2003, 2007, 2008; Kaczmarek, 1991; Leischner, 1991; Bäzner & Hennerici, 2007; Piechowski-Jozwiak & Bogusslavsky, 2013).

The relationship between brain disease and artistic creativity is particularly complex: neurological conditions after differentiated brain damage can lead to difficulties or even the inhibition of creative work in many areas (Sadana et al., 2017). Brain damage can also influence changes in the creative workshop, the method of creation or artistic style and lead, for example in people with an initial loss of creativity, to surprisingly innovative workshop solutions (Pąchalska, Bednarek, et al., 2020). In recent years, authors have highlighted the links between the creation process and the self system and the changes that this system undergoes as a result of various brain injuries. New research conducted in this field (Pąchalska, Bednarek, et al., 2020) allows one to redefine this term as well as the subject and purpose of research on the neuropsychology of creativity.

The neuropsychology of creativity is a subdiscipline developing on the borderline of: *medical neuroscience* — using clinical and experimental neuroanatomical, neurophysiological, neurobiological, neurosurgical, neurological, neuropsychiatric, and *social neuroscience* — using social psychology and neuropsychology, social linguistic and neurocultural studies to help disabled people, with a particular focus on artists with brain damage (Pąchalska, 1977). The subject of research on the neuropsychology of creativity is the relationship between creativity and the functioning of the brain (structures and connections) and the self using the individual, social and cultural mind and modeling these behaviors in relation to the biological organism and the social and cultural environment.[1] The goal of neuropsychological research is to understand the brain conditions of the psyche and human actions, i. e., reaching the neural basis of motivation, cognitive and emotional processes, and explaining the human behavior and neurophysiological factors conditioning our needs, aspirations, attitudes, values, and above all the brain foundations of the existence of any consciousness self and identity. The ability to create new things is not just the domain of outstanding individuals. The creative potential lies in every human being, and whether it is liberated and directed to creating things of a supra-individual significance depends on many conditions and circumstances deserving separate discussion (cf. Brown, 2017).

[1] The human brain does not work in isolation from the body and from the social and cultural environment (Luria, 1963).

Main Features of Creativity and Creation

Creativity is a versatile and abstract human ability which has been defined in numerous ways; its most consensual definition conceptualizes it as an ability to yield products (e. g., ideas, stories, objects) that are both novel (i. e., original) and useful (Stein, 1953; Sternberg, Lubart, Kaufman, & Pretz, 2005). Cognitively, creativity has been conceptualized as a higher order thinking ability involving analysis, evaluation and synthesis i. e., the creation of new knowledge (Sadana et al., 2017; Abraham, 2018).

The main features of creativity — in all areas — *first*, are *novelty, originality* and *precursor*. This is emphasized by numerous definitions of the word, for example: creativity means a product possessing the value of novelty (cf. Brown, 2017). In other words, the introduction of something innovatively new and positive for society that goes beyond the familiar and accepted (Zaidel, 2014). However, the essence of creativity is not about creating what is not and never was in the work, but rather about re-imagining and transforming what exists and is available to everyone, the discovery of previously unnoticed connections between elements of the studied reality or a new approach to the reality presented in works of art (Pąchalska, 2007). The task of thinking differently requires generating creative, innovative responses to popular items (e. g., the use of a metal tube). The idea itself is associated with both consciousness and imagination, while searching for possible alternatives requires a greater association of meanings and memory capacity, including semantic memory (Storm & Angello, 2010). Accordingly, Boden (2013) has divided creativity due to product type into:

- *psychological creation* (close in terms of subjective creativity) leads to new creations only for the author;
- *historical creation* (close to objective creativity), which is new throughout history.

The second, and also an important feature of creativity, is *functionality*, sometimes also called utility in the broadest sense. The result of creativity cannot be useless and it is difficult to imagine the situation of creating anything without — even vague and indefinite — the idea of the function of a new product (Brown, 2017). This means that the effect of creative activity is to meet specific needs in a way better than the existing ones, sometimes it can even make/evoke the needs not previously known and not felt. It has long been believed that all creativity is intended to multiply good (in the broadest sense) and prevent evil (Pąchalska, 1977; Williams K. J. H. et al., 2018). However, also creating seemingly useless things, if it adds a new thread to the resource of good things, promotes development, self-realization, well-being, and even gives pleasure in creating. Creative activity is a way to develop a lifestyle based on self-creation and self-realization (Pąchalska, Bednarek, et al., 2020).

*The third***,** also an important feature of creativity, is *communication*. Kaczmarek (1991) has stated that a symbolic communicative system practiced only by humans, and is argued to have become a fully practiced behavior at a time when early human social groups grew in size and complexity, and communication through language and art promoted cohesion and survival. Luria (1976) pointed out that the roots of creativity reach deep and go beyond

communication and social contexts. He assumed that the basic biological needs of animals, the need to preserve physical energy and survival, the occurring threats (illness or death) can be the main motivators of innovation also in art. Given the adaptive evolutionary processes, it is reasonable to assume that these needs have been woven into the brain's creativity mechanisms in humans (Brown, 2017). This means that there is a deep motivation to communicate through art, even if there is no language communication after brain damage. In such neurological cases, the very transition to creation is innovative, but the final product is not necessarily a work of art (Pąchalska, 2007; Zaidel, 2013a, 2013b, 2013c).

The Essence of the Creative Process

The creative process is a weave of unconscious and conscious dynamic states of mind, the essence of which is the artist's search for "non-existent" objects, including signs and their meanings, followed by their processing and final execution of the work. As was stated by Pąchalska, MacQueen, and Brown (2012) the central property of an original act and the crux of creative thought is a departure from habit or expectancy. This could be construed as a failure of repetition since each recurrence is minimally novel in comparison to its antecedents, in part due to changing sensibility, in part to fluctuations in the resting state. Incessant change is introduced along with continuity in the revival of mental states, in the growth of private experience and the passage of objects in the world. The continuity resolves the sameness of things with novelty in their recurrence. Whether a thing changes rapidly — a film, an argument — or slowly — the self, a rock: the transition over moments is continuous. The paradox is that in spite of continuity, things exist as a single brain/mind state (epoch) of becoming with no gaps in experience or perceptible nature.[2] Things recur and each recurrence is novel though retaining ingredients of the prior single brain/mind state (epoch). The difference between exact iteration, novelty in passage and fresh renewal depends on more than a difference in succession since a world in continuous change is the main source of the disparity, and a self of moderate stability is the arbiter of sameness and difference (see also Brown, 2017).

In this context it is important to emphasize again that genuine change occurs in the actualization of the brain/mind state (epoch), and that apparent or illusory change occurs in the transition of one brain/mind state (epoch) to another. Genuine change is the becoming-into-being (existence) of an entity — the actualization of a sequence of categories — while apparent change is the progression from one brain/mind state (epoch) of being to another, namely, the observed and presumed causal sequence of events in the world. An epochal state is an instance of being that is inert, its dynamic — becoming — exhausted in its formation. The process of entity creation is complete on the actualization of an epoch of being (category, substance), which on achieving existence passes away in its replacement, while continuity depends on the overlap of epochs (see *Figure 1*).

[2] Even across sleep or loss of consciousness there is felt a continuity of the self.

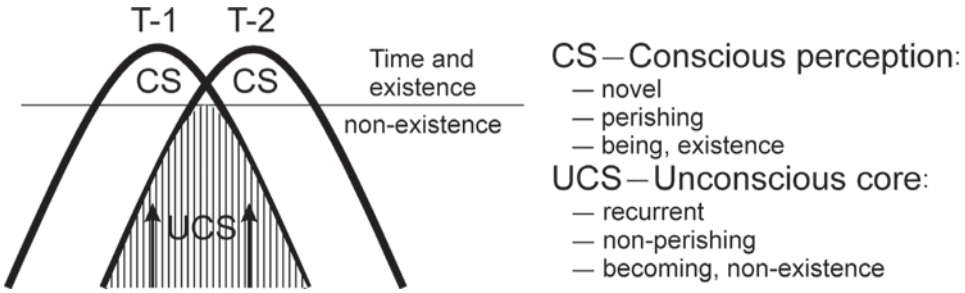

Figure 1. Phases in working memory are generally revived in ensuing states in the order of their registration, i. e., in relation to their resemblance to the oncoming brain/mind state and, thus, their capacity for revival. Images closer to the current perception, i. e., those in short-term memory that almost achieve re-perception, are most likely to be revived in the current metal state. The brain/mind state at T-1 is replaced by an overlapping state at T-2. The core of T-1 is overlapped at T-2 before T-1 terminates, i. e., before the epoch exists. This explains the recurrence of early phases in T-1 associated with individuality, self, character, dispositions, long-term and experiential memory, and the "persistence" of core beliefs, values and personality. Later phases perish on completion of the entire state to make way for novel perceptions. There-activation of earlier phases by the overlapping state explains the sustained personhood behind succession. Early phases are an ingredient across states, later ones are malleable to a greater extent as the endogenous process is shaped by sensation.
S o u r c e: Pąchalska et al., 2012

The brain creates ideas based on insights. The duration of the image depends on a whole range of features, where emotions play the main role. Pleasant events are subjectively perceived as shorter (e. g., meeting with a friend), unpleasant events have a subjectively longer duration (e. g., waiting in the waiting room for a dental procedure). Thus, the event has a more or less arbitrary duration in a series of repetitive brain/mind (epoch) states. The exchange rate is probably constant for each unit. The dynamics of the brain/mind state are associated with changing objects and events, and with our attitude to them. The real change in the mind of the observer is imperceptible.

The Roots of Creativity

Looking at the fascinating creations of artistic craftsmanship, we wonder how their creators invent such "ready" works. Zaidel (2014) suggests that, given the biological and neurological basis of brain function, human creativity has at least three perspectives:

1) *biological*, which includes innovations related mainly to the needs and motivation of the individual (the roots of creativity run deep and are not necessarily limited to social or communicative considerations);
2) *neuroanatomical,* which includes innovations related to differences between individuals in the size and organization of the brain, the number and quality of neuronal connections and neurotransmitters;

3) *neurological,* which includes innovations related to the consequences of brain damage and their references in visual arts (in artists with brain damage forming various disease syndromes).

Biological underpinning, which includes mainly research on the biological foundations of creation, has been conducted for several years and concerns both animals (Hinde & Fisher, 1951; Benson-Amram & Holekamp, 2012) and humans (Zaidel, 2014). Compared to humans, however, innovations by animals are far fewer (Laland & Reader, 2010; Lefebvre, 2013). Given adaptive evolutionary processes, it is reasonable to assume that all of these have become interwoven into the underlying brain mechanisms of creativity in humans (Pąchalska, 1999; Brown, 2017). Nowadays, work is underway on the relationship between gene expression, and behavior, mainly creativity (Pąchalska, Bednarek, et al., 2020). These studies include the conclusion that a person capable of innovation is motivated mainly by biological to survive, which has been linked to other, unique creative abilities.

Neuroanatomical underpinning includes mainly the comparison of the human brain to that of monkeys with fMRI having revealed several corresponding structural and functional networks, but two that are unique to humans (Mantini, Corbetta, Romani, Orban, & Vanduffel, 2013), that is, the left hemisphere language network and the left fronto-parietal network. Using MRI for brain structural and parcellation analyses, investigators (van Essen, Glasser, Dierker, Harwell, & Coalson, 2012) have found a larger left Sylvian Fissure, which includes the parietal operculum, and in the medial temporal cortex, the portion with the lingual gyrus and collateral sulcus (all critical in language functions); in the right side the angular gyrus and dorsomedial prefrontal region. Such asymmetries are not found in other mammals, and could play a functional role in human creativity. In this trend, research is conducted on the relationship of neurotransmitters and creative activity. For example, deficiency of serotonin and related depression promotes the creation of sad works painted in black colors.

Neurological underpinning includes mainly observations of various brain damage effects on the creativity of visual artists. Approximately 80 cases or so with such damage (mainly in one side of the brain, and where the etiology is commonly stroke or brain cancer) have already been described in the neurological literature (Kaczmarek, 1991; Pąchalska, 1999, 2003, 2007, 2008; Rose, 2004; Bogousslavsky & Boller, 2005; Zaidel, 2005, 2013a, 2013c; Finger, Zaidel, Boller, & Bogousslavsky, 2013; Mazzucchi, Sinforiani, & Boller, 2013; Piechowski-Jozwiak & Bogousslavsky, 2013). They can help show the way to the neuroanatomical and neurofunctional foundations of creativity. The key questions concern post-damage alterations in creativity, as well as loss of talent, or skill (Zaidel, 2014).

However, Luria, Karpov, and Yarbus (1966), describing the multifaceted nature of the roots of human creativity, drew attention not only to the above-mentioned perspectives, but also to the system of the self and the artist's identity associated with it (cf. Pąchalska, Bednarek, et al., 2020). It is presumed, that human creativity, both healthy and with brain damage, like many other activities, is usually a response to its various needs associated with the emotional component (cf. Pąchalska, Bednarek, et al., 2020). In this context, it should be

noted that for the artist, creativity in itself is a need, often strong, that requires immediate satisfaction. The artist sees in the world the lack of something, which is a product existing so far only in his imagination. The very process of creation meets the need to fill this gap, but its satisfaction is only possible after the creation of the work or at least a part of it. Cultural patterns in the brain, which are made aware or unconscious, play a specific role here, but act in individual states of mind as a kind of internal constraint (Pąchalska, 2019).

Objective

Research in the neuropsychology of creativity has focused on the creative process and neurocultural studies are still in their infancy. Only recently have they joined the empirical aesthetics that was introduced in the 19th century by Gustav Fechner (Fechner, 1876). It is difficult to say whether neuroscientists consider this topic worthy of deeper scientific studies, of course with rare exceptions (Pąchalska, 1999, 2019; Augustin & Wagemans, 2012; Pąchalska, Bednarek, et al., 2020).

A number of reports have examined the development of visual artistic ability following degenerative or other types of brain injury (Zaidel, 2005; Chatterjee, 2006; Pąchalska, Buliński, et al., 2013). However, the emergence of *de novo* artistic ability is rarely seen in brain-damaged patients (Pąchalska, 1977; Pollak, Mulvenna, & Lythgoe, 2007; Piechowski-Jozwiak & Bogusslavsky, 2013); this is particularly true for patients with traumatic brain injury (Schott, 2012; Grochmal-Bach et al., 2009; Midorikawa & Kawamura, 2015), autistic patients (Sacks, 2004; Baron-Cohen, Ashwin, E., Ashwin, C., Tavassoli, & Chakrabarti, 2009), schizophrenia (Pąchalska, Grochmal-Bach, MacQueen, et al., 2008) or stroke (Pąchalska, 1988; Pąchalska, Grochmal-Bach, Wilk, & Buliński, 2008; Kaczmarek, 1991; Kaczmarek, Code, & Wallesch, 2003; Code, Joanette, Lecours, & Wallesch, 2003).

The aim of the present paper is to present the brain mechanisms of creativity. It discusses the neuropsychology of creativity as a subdiscipline developing on the borderline of: (1) medical neuroscience — using clinical and experimental neuroanatomical, neurophysiological, neurobiological, neurosurgical, neurological, neuropsychiatric and (2) social neuroscience — using social psychology and neuropsychology, social linguistics and neurocultural studies to help disabled people. In addition, a review of opinions of various authors from around the world on the relationship of the healthy and the damaged brain with creativity is presented in the paper.

Case Study

When describing the neurological and neuropsychiatric basis of the creativity of people with various brain injuries, one should take into account the possibility of the co-occurrence of various disease syndromes or the overlapping of symptoms one on another. That is why good syndrom diagnosis as initiated by Luria (1976) is extremely important, sup-

ported, if possible, by the designation of the neuromarkers of a given disease entity since very often we are dealing with false diagnoses (Pąchalska, Kaczmarek, & Kropotov, 2014).

It is well known that brain damage can lead to various focal and generalized neurological disorders. There is, however, only one report on the potential changes in artistic output following multiple disorders, that is schizophrenia complicated with head injury and post-traumatic depression (Pąchalska, Grochmal-Bach, MacQueen, et al., 2008; Pąchalska, Grochmal-Bach, Wilk, et al., 2008). He was a well-established painter (WW, born in 1940), who was diagnosed at the age 18 with schizophrenia. As a part of psychiatric rehabilitative therapy, he received art therapy, during which he developed sophisticated painting skills, enabling him to become a successful painter widely recognized by critics. He portrayed his own visual hallucinations (see *Figure 2*), mainly using recollected contents rather than active/ongoing visions, when painting.

Figure 2. Painting entitled "Laboratory" created before the accident based on the artist's visual hallucinations.
S o u r c e: clinical material of M. Pąchalska

One day, while actively hallucinating and feeling able to fly with wings, he rushed into the street and was knocked down by a car. He was unconscious for 5 hours, with a brain injury involving the subcortical anterior frontal areas, and with subsequent asymmetric frontal lobe atrophy predominating on the left side (see *Figure 3*).

After the injury, his painting style changed with a significant reduction in the hallucinatory content. The subjects became more traditional with a selection of hues now dominated by blunt and earthy colors. He also showed signs of perseveration in repeating the reproduction of the same objects or faces.

Over time, his psychiatric condition deteriorated and 10 years after his accident, he had another psychotic burst, also with progressive memory disorder. On detailed neuropsychological assessment, he showed visual memory deterioration, executive dysfunction, and hemispatial neglect (see *Figure 4*).

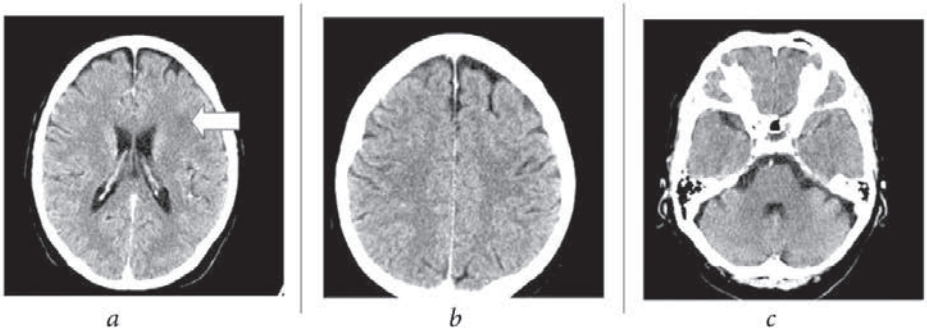

Figure 3. Computed tomography of the brain done 15 years post trauma: *a* — arrow shows a hypodense subcortical left frontal lesion; *b* — asymmetrical cortical atrophy more pronounced on the left; *c* — right anterior temporal lobe and cerebellar atrophy.
S o u r c e: clinical material of M. Pąchalska

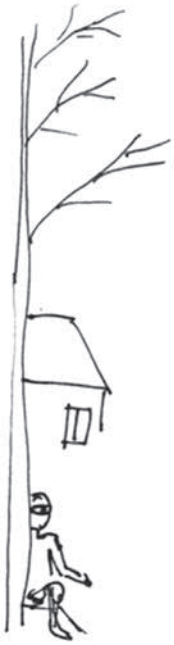

Figure 4. A drawing of a person, a house, and a tree showing left hemispatial neglect.
S o u r c e: clinical material of M. Pąchalska

The patient took part in an intensive cognitive neurotherapy program run for two years, four times a week. Transcranial direct current stimulation (tDCS) was used to reduce depression in combination with the Therapy of Symbolic Thought (see Pąchalska, 1977, 1991, 2003; Kaczmarek, 1991). After a year of therapy, significant improvement in all cognitive functions was obtained. In the painting, the features of side skipping disappeared, but the patient was still signaling his sadness and social isolation (see *Figure 5*).

Figure 5. A drawing of "my illness" showing sadness and social isolation. In the right corner the artist wrote "a bird came to advise on something".
S o u r c e: clinical material of M. Pąchalska

The inscription on the engraving "a bird came to advise on something" and the subsequent interpretation of the work by the artist suggests that only a bird can advise on something, because people do not understand his sadness and social isolation.

Prevalence of Depression and Schizophrenia Neuromarkers

Neurophysiological studies (neuroimaging studies of the brain, quantitative electroencephalography (qEEG), event-related potentials (ERPs) and sLORETA tomography[3] (see Kropotov, 2009, 2016) were very useful in the confirmation of his neuropsychological and neuropsychiatric diagnosis.

A comparison of studies conducted before therapy (study 1), after a year (study 2) and after two years of using neurotherapy (study 3) shows significant (even spectacular) changes in the EEG spectra that occurred during all three recordings (see *Figure 6*).

It is noteworthy that in the first recording conducted in the examined patient before therapy, slow alpha (about 8 Hz) rhythms obtained from F7 and F8 sites were noted. These slow alpha rhythms reflect a statistically significant deviation from the norms in individual spectra.

[3] The studies described here are looking for the neuromarkers of mental disorders (Kropotov, 2009, 2016; Kropotov, Pronina, Polyakov, & Ponomarev, 2013; Pąchalska, Buliński, et al., 2013; Pąchalska & Kropotov, 2020). The concept of neuromarker was defined by K. J. H. Williams et. al. (2018) as a narrower version of the biomarker. In the case of EEG recordings, neuromarkers in the form of amplitude of EEG spectra and ERPs are considered to be two important factors giving insight into the functioning of the brain: spontaneous EEG recording shows the mechanism of cortical self-regulation, while ERP reflects the flow of data at particular stages of their development in the brain.

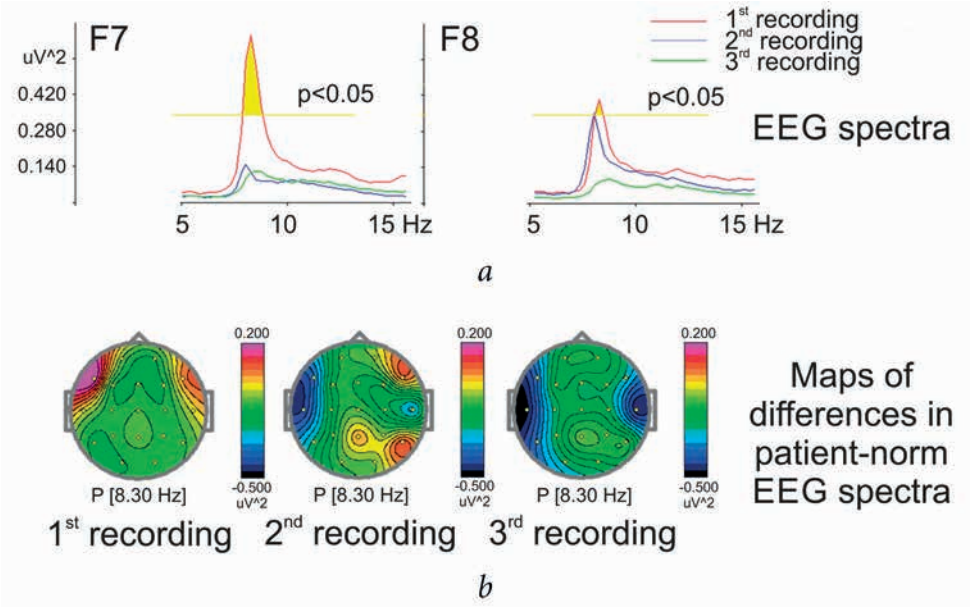

Figure 6. EEG spectra obtained in the GO / NOGO task in three recordings from the electrodes applied in places F7 and F8, 1st recording — red curve, 2nd recording — blue curve, 3rd recording — green curve. The peaks in the spectra obtained during the first recording correspond to an alpha rhythm of about 8 Hz. The yellow horizontal line shows the confidence level ($p < 0.05$) in the range of deviations from the normative mean (*a*). Maps of EEG spectra with a value of 8.3 Hz during three recordings (*b*).
S o u r c e: Pąchalska et al., 2014

Extracting the independent components from the spontaneous EEG recording during the first recording revealed the presence of two independent components generated in the left and right prefrontal cortex respectively (see *Figure 7*). In the second recording, there was a large loss of alpha rhythm in the left lower frontal cortex, which completely disappeared in the third recording.

Earlier research by Kropotov et al. (2013) showed that the difference in the ERP wave obtained in the record when performing NOGO-GO tasks can be considered an indicator of the cognitive control. In *Figure 8* I present the mean for ERPs wave differences in healthy subjects and in patients with diagnosed schizophrenia from the Human Brain Index (HBI) normative database in Chur, Switzerland. It can be easily observed that the difference in waves from the electrode recording at the Cz point rapidly decreases in patients with schizophrenia. It should be emphasized that the patient under discussion had a wave distribution similar (see *Figure 8*, on the right) to patients with schizophrenia (see *Figure 8*, on the left), because in all three records a clear delay or reduction of the differences between the waves is observed. At the same time, the positive wave recorded from the electrode placed at T5 did not change.

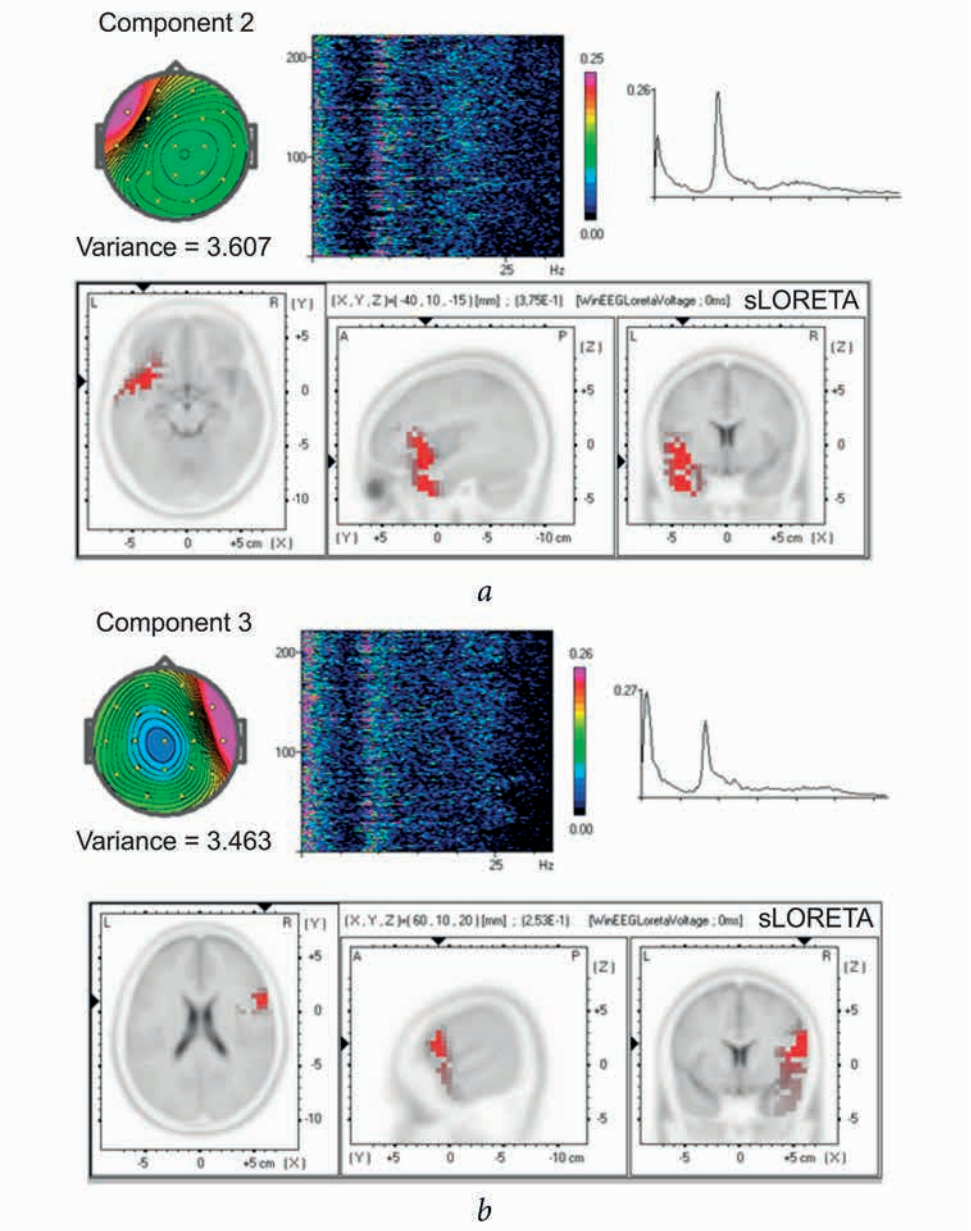

Figure 7. Independent components extracted from the first EEG record: *a* — independent component generated in the left hemisphere: top (*from left to right*) — topography, spectra coded for 4-second periods, calculated for the entire 20-minute recording, averaged component spectra; bottom — topography image obtained in sLORETA tomography; *b* — independent component generated in the right hemisphere: top (from left to right) — topography, spectra coded for 4-second periods, calculated for the entire 20-minute record, averaged spectra of the components; bottom — topography image obtained in sLORETA tomography.
S o u r c e: Pąchalska et al., 2014

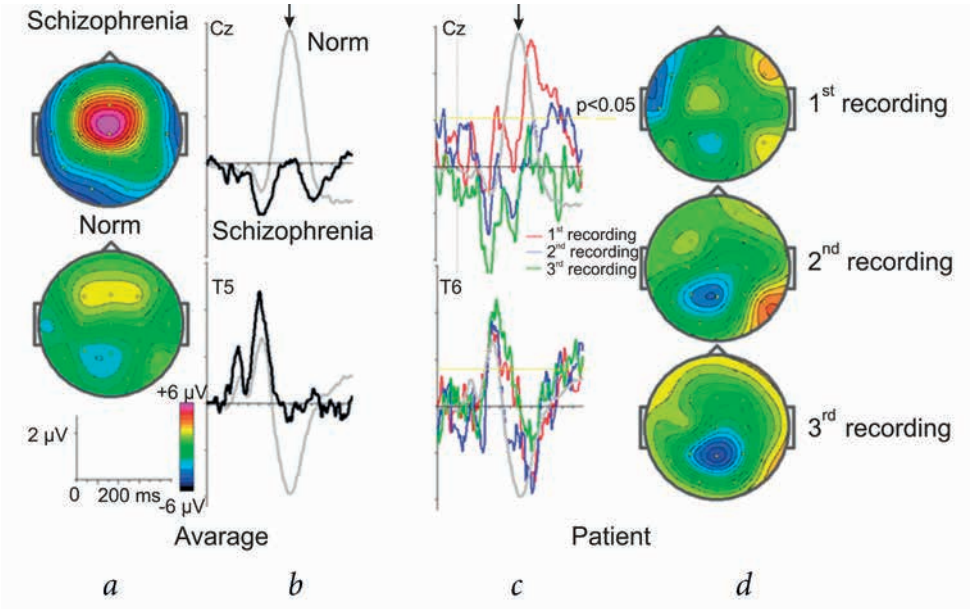

Figure 8. Differences in ERP waves in NOGO-GO type tasks in the examined patient in comparison with healthy individuals and schizophrenic patients: *a* and *b* — the average of ERP wave differences from the records taken from the electrodes applied at Cz and T5 points in a group of healthy individuals ($n = 61$) and a group of patients with schizophrenia ($n = 28$) selected by age, and wave difference maps at 390 ms (marked with an arrow); *c* and *d* — individual differences in ERP waves in three records made in the examined patient from electrodes applied at Cz and T5 points. Right — wave difference maps at 390 ms (marked with an arrow).
S o u r c e: Pąchalska et al., 2014

It can be therefore concluded that the studied patient had a neuromarker of disturbed cognitive control which could be an index of schizophrenia. This is associated with a decrease in ERPs wave form recording during NOGO-GO tasks. As numerous studies have shown, including mine, this neuromarker occurs in most patients with schizophrenia (Kropotov et al., 2013; Pąchalska, Pronina, et al., 2013; Pąchalska et al., 2014). At the same time, the positive wave recorded from the electrode at the T5 point did not change in study 3. This means that the Therapy of Symbolic Thought did not affect this neuromarker. This means that it can be used to confirm or exclude a diagnosis of schizophrenia (see also Pąchalska et al., 2014).

It is worth mentioning that the variability of schizophrenia symptoms (acute psychosis), cognitive deterioration and periodic intensification of symptoms associated with previous brain trauma (e. g., periodic depression) may have been related to the content and form of the subsequent paintings painted by this artist. Therefore, his artistic output change is rendered particularly complex and difficult to interpret, given the superimposition of neurological and psychiatric conditions (see *Figure 9*). This self-portrait was paint-

ed a few days after the cast of acute, transient psychotic disorders according to the ICD-10 code coding F23. During this period, the patient experienced hallucinations, delusions and perceptions. These symptoms started suddenly, had great strength and subsided after three weeks. According to the patient, the symptoms were caused by the death of a close friend. It illustrates the artist's state of mind.

Figure 9. Self-portrait created during the Therapy of Symbolic Thought, a few weeks after acute psychosis.
S o u r c e: clinical material of M. Pąchalska

The analysis of the work shows that various aspects of the sense of his own self have been disturbed. These include:

1) *disturbance in the sense of separateness of the self from the environment* — body fragments of the presented figure leave its borders, merging with the hallucinated external reality, and this reality breaks into its interior, blurring the boundary of the self from the outside world;
2) *disturbance of the sense of unity (identity) of one's self*, which is multiplied, gender identification is disturbed, the character has been placed in a dream-like world. Within and on the border of the body there are still other deformed figures not belonging to the real world;
3) *disturbance of the sense of coherence of the biological self*, its own body has undergone transformations. The picture shows one person representing the artist who has three faces with four eyes and three noses and lips. We also see four hands belonging to no one and mysterious, unidentified beings who invaded the open body of the represented figure;
4) *disturbances of the feeling of having internal content,* both the interior of the figure representing the artist and the background of the image are full of symbolic,

hallucinated performances whose meaning remains unclear; some symbols are religious, others refer to dream-like or esoteric (occult) phenomena.

Particularly noteworthy is the fact that subsequent images created in the process of neurotherapy did not bring about a great change in the artist's style of creation. The patient expressed his dissatisfaction with the few sketches he had made for the pictures. The breakthrough in the artist's work occurred when his work was stolen from the exhibition and in compensation he received €1000 from the organizers, which changed his self-esteem and attitude towards the images he had created. He came to the conclusion that his works were of great value. The award system launched at that time made the artist enthusiastically set about creating further works. During this time, over 30 self-portraits were created in the form of 3 heads (see *Figure 10*). In his opinion, all these paintings

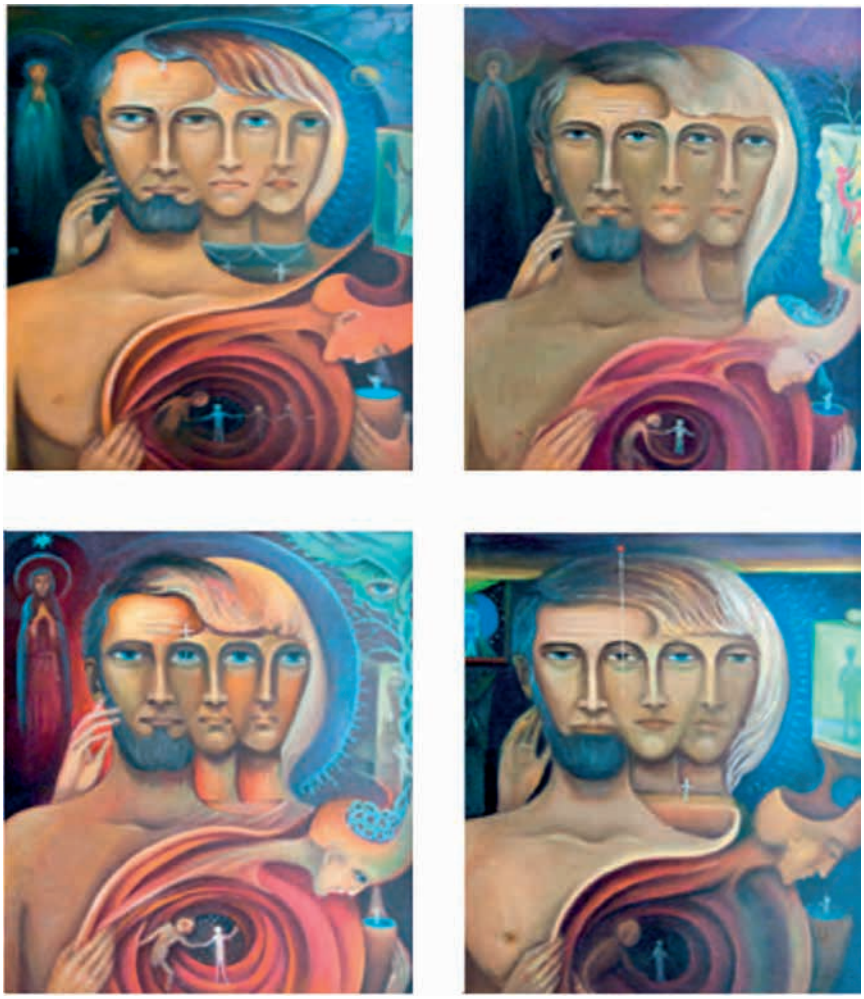

Figure 10. Perseverated self-portraits created during the Therapy of Symbolic Thought.
S o u r c e: clinical material of M. Pąchalska

were new and different works. The patient was very happy after painting each of these self-portraits. However, according to critics, this works resembled, to a greater or lesser extent, the first of the painted self-portraits. According to neuroscientists, these were likely to be classified as perseverations associated with damage to the brain's frontal lobes, and disturbances to the working memory.

The above example of WW patient's creativity shows us the importance of self-awareness, cognitive processes, with particular emphasis on attention and working memory), emotional and executive in creativity. It also indicates the holistic brain activity (Luria, 1976, 1979) or equipotentiality (Lashley, 1951), its holographic organization (Pribram, 1984), and even the function of the brain and mind not only in space and time, but also in a pulsating state in hyperspace (Pąchalska, 2019), presented in the author's synchronous memory model (see *Figure 11*).

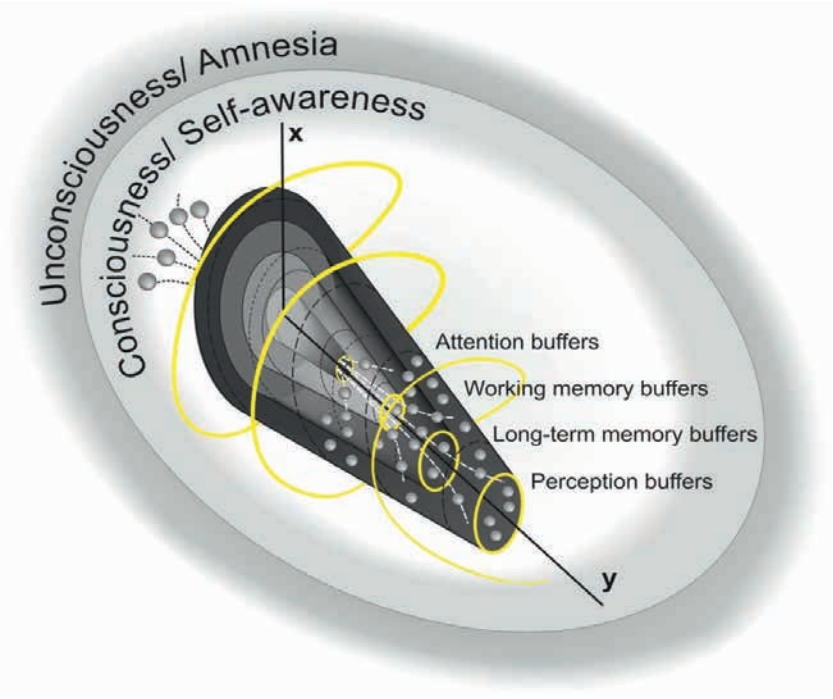

Figure 11. Synchronous memory model.
S o u r c e: Pąchalska et al., 2014 (modified)

The spatial arrangement of the model makes it possible to present on the *x* and *y* axes the relationship between the general structure of attention and memory systems (in terms of the number, content and complexity of the processed elements) and the period of time necessary to process them. It can be seen that the attention buffers transfer data to the working memory buffers. This system, according to the latest data obtained in neurophysiological studies, processes the smallest number of elements in the shortest possible time: seconds or even milliseconds (Kropotov, 2009; Brown, 2017). As the num-

ber of elements of information processed and/or the duration of the processing exceeds a certain threshold, we gradually move from the attention system (several stimuli, several milliseconds) to the working memory system (several to several dozen stimuli, several milliseconds to several seconds and/or minutes) depending on the capacity of the working memory buffer (see also Pąchalska et al., 2014).

In a similar way, there is a transition from the working memory system to the long-term memory system. The boundary of the transition is difficult to determine precisely and most likely it is actually not very sharp. In the human brain, a continuous process takes place, lasting from milliseconds to entire years when information is remembered, stored, reproduced and forgotten. Also, semantic and episodic memory is associated with the number, time as well as the content and complexity of the processed data (see Pąchalska, 2007, 2008). The differences between these types of memory mainly concern the content of information. Of course, the longest storage time is characteristic of long-term memory, which is why we put it at the basis of the presented model. This is closely related to the organization of one's self in time. Artists with brain damage as a result of the collapse of the memory system may change the style of creation (cf. Schott, 2012; Piechowski-Jozwiak & Bogusslavsky, 2013) but also they will not be able to change the pattern of creation and will repeat the same pattern in subsequent works (cf. Pąchalska, 2019).

Returning to the division of creativity by Boden (2013), a work created for the first time, as long as it has features of novelty, can be classified as a historical creation (close to objective creativity), which is new in the entire history of creativity, and even recognized by critics for being transgressive (Toeplitz, 1991). The perseverance mechanism associated with damage to the frontal lobes may deprive the artist of this feature and the work will have only the features of psychological creation (close in terms of subjective creativity) leading to new creations only for the author. The patient presented here claimed that he created only new works, but they were, according to critics, new only to him. It is worth noting, however, that from the patient's perspective, many factors influence such a style of creation and its assessment. Perhaps the most important factor is that the patient has difficulties in introducing a new topic to his work. However, the painted works have objectively smaller or larger differences of detail, which illustrate the varied states of consciousness experienced by this patient and painted (more or less consciously) in subsequent works. Therefore, it is difficult to state unequivocally whether we are dealing here only with perseverations and with compulsive returns to the same motif due to brain damage. Before the illness, this artist was a professional with educated skills and artistic self-awareness. He probably also knew that in the history of art there were many artists who repeatedly returned to the same motif and who built their works from repetitive elements — contrary to the common rule that the artist is required to be unique and to create unique works.

As Pablo Picasso claimed, "One would like a man not to be repeated. Repetition is against the laws of the mind, its forward course" (Toeplitz, 1991, p. 131). Therefore, it is worth taking a closer look at the functions of the repetitions used. Sometimes they were study series, in which the artist penetrated into very subtle shapes and shades

of repeated motifs, sometimes also subsequent approximations of the ideal were created in the imagination of the creator. In modern art there is even a fashion for multiplication of the theme. This included, for example, Andy Warhol (1928–1987) the well recognized American artist, one of the chief representatives of pop art, known primarily from simple and serial sets with different color contrasts, which included, for example, repeated portraits: Brigitte Bardot, Marilyn Monroe, Elvis Presley, Jacqueline Kennedy Onassis, Marlon Brando, Elizabeth Taylor. Repeatability can become one of the means of expression, fulfilling the functions of either describing the state of modern culture in which stereotype, punch and uniformity dominates, or rebellion against these phenomena, which can also be interpreted as a manifestation of transgression (Pąchalska, Kaczmarek, & Bednarek 2020).

The patient example presented above allows us to understand how difficult it is, even for an experienced researcher, to interpret the creativity of a patient with brain damage. It is necessary to take into account the patient's life history, type, place of brain damage and symptoms that have developed as a result of this damage at various periods of time, e. g., the development of post-traumatic emotional disorders, frontal syndrome, including depression and anxiety, and the destabilization of the self system (Pąchalska, Kaczmarek, & Kropotov, 2020). Therefore, one would have to agree with Luria et al. (1966) that the process of creation is closely related not only to the functioning of the brain, but also to the proper functioning of the individual self system, including the social and cultural one. It depends on the integration and interaction of all types of self and it is closely related to the process of creation.

Integrated Self System and Creativity

Integrated self system included the individual (objective and subjective) and social (collective and cultural) self (Pąchalska, 2019; Pąchalska, Kaczmarek, & Bednarek, 2020). This concept, however should include the minimal (working) and longitudinal (autobiographical) self, which is the basis for the formation of the self system. Therefore, I have developed a modified model of the self system, which requires the nesting of the minimal (working) and longitudinal (autobiographical) self and a change in understanding of the concepts of individual and social self in terms of the thought process (see *Figure 12*). Therefore:

1. The individual self includes:

- the objective self, understood as the organism, i. e., in Goldstein's (1995) approach, the body together with its states and processes occurring in it. The subject self has consciousness, but it lacks self-awareness and meta-consciousness (awareness of mental operations on its own subject). The subject does not express their own thoughts but acts according to ready-made schemes: he/she is not the author of the selves. As soon as you realize the existence of the outside world, your subject self also becomes the object of perception. This process enables the subjective self to be formed;

- the subjective (cognitive) self, having consciousness, self-awareness and meta-consciousness, enabling one to know oneself and act in accordance with one's own needs and values as well as the requirements of the environment. He/she has a sense of separateness, autonomy, insight (introspection), the possibility of self-assessment and self-control and creativity (see Pąchalska, 2008). The subjective self conditions the appearance of individual identity.

2. The social self, includes:

- the relational self, understood as an image and description of the You — You (interactions), from an individual and social perspective taking into account relationships with other important people and social groups around which, according to Richard Brown (1987), social identity develops.

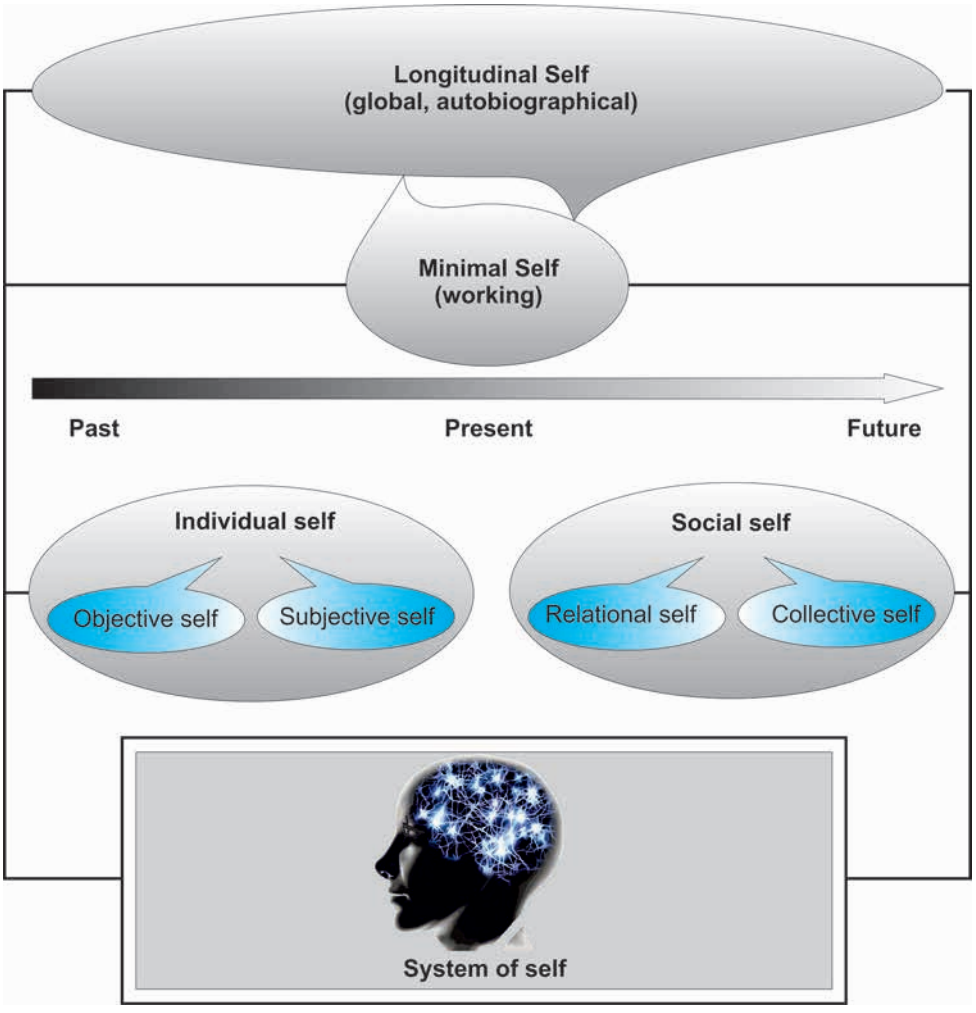

Figure 12. Process model of the system of self (modified).
S o u r c e: M. Pąchalska, 2019

- the cultural self, understood as an image and description of the We — We from an individual and social perspective including nesting in the culture or subculture of a given social group around which cultural identity develops.

The microgenetic approach to the self-system takes into account the concept of the nesting of the minimal (working) and longitudinal (autobiographical) self in the individual and social self in the processual approach, and creates the basis for the development of the self system. It also allows for a better explanation of the disruption or disintegration of this system in people with various kinds of brain damage. It also allows for more effective rehabilitation interactions to be offered to these people (see also Prigatano, 2009).

People with brain damage exhibit disturbances in logical or spatial coherence depending on the location of the damage (structures and neural connections) in the right or left hemisphere of the brain. Linguistic representations are more or less disintegrated, which makes creating language constructions more difficult, as a result of which the process of creating ideas about yourself and the world is disturbed, which is why the image of oneself and, as a result, the whole system of the self is disintegrated. Damage to the subcortical structures and connections is also not without significance, however, the picture of disorders is different, something which is described in more detail as detailed in another work (Pąchalska et al., 2014).

What Drives Anyone to Create?

What goes on in our bodies and minds when we begin to explore creative possibilities? What was the feeling that made a particular person want — so deeply — to create something almost randomly? What in the brain triggers the moment of "rising above" established knowledge, and why are some individuals exceptionally creative: are all questions that are still being explored (Barbey, Colom, & Grafman, 2013; Jung & Haier, 2013). At the same time, several creativity-related factors have already been identified, specifically brain size in innovative animals (Lefebvre, Reader, & Sol, 2004), neurotransmitters (Manzano, Cervenka, Karabonov, Farde, & Ullen, 2010), intelligence level (Lefebvre, Reader, & Sol, 2013; Brown, 2017), ecological niches (Lefebvre, 2013), personality and identity attributes (Pąchalska, 2019).

One of the most important factors, without a doubt, is social recognition variously understood, which activates and strengthening the reward system (see *Figure 13*).

Pleasant experiences release positive emotions (e. g., joy), because they stimulate the reward system by creating connections from the basal part of the frontal cortex to the anterior (emotional) part of the anterior cingulate cortex of the right and the left haemisphere. At the same time, the punishment system is weakened. The strength and duration of these emotions are associated with the importance of the event for the artist. Therefore, exhibition, and the positive reactions of the audience, might modify the minimal (working) self, and the longitudinal (autobiographical) self, strengthening the significance of a given (negative or positive) event (see Pąchalska, 2019).

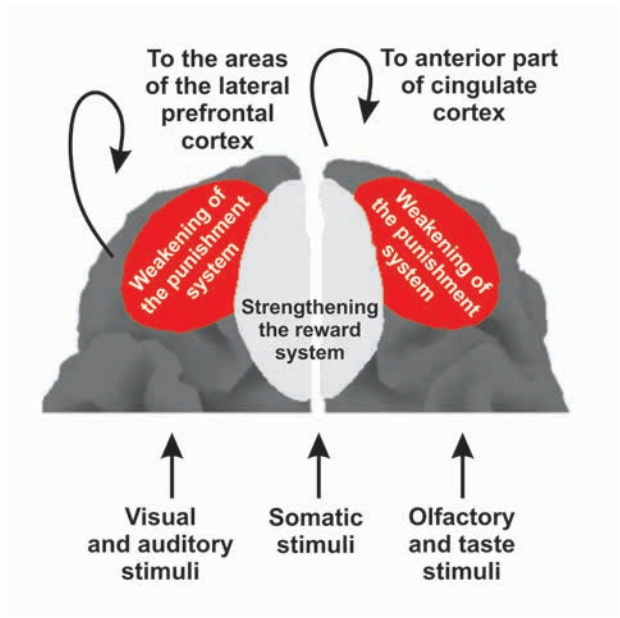

Figure 13. The reward / punishment system.
S o u r c e: Pąchalska et al., 2014 (modified)

Individual, Social and Cultural Conditions of Creativity

Many years of scientific research has allowed us to conclude that creative abilities are conditioned both in the norm and in pathology by the self system. The conscious Self creates an image of itself and the world in connection with its organism and the socio-cultural arena, especially with its own social group. The organism ensures survival and development, and the socio-cultural arena provides norms and rules of social life as well as cultural values and patterns. In this discourse between various types of an individual, social and cultural self, a unique interpreter of the world is created for each person and for only them (see Gazzaniga, 2011). Its creation constitutes the action of related factors (see *Figure 14*), which include:

1) *the brains and its codes*, i. e., undisturbed electric and chemical code (neuronal connections and neurotransmitters);
2) *the individual mind and its codes*, i. e., mono-specific, poly-specific, hierarchical and creative codes, developing on the basis of cognitive processes (including language and non-language communication) and emotional processes. This ensures metacognition, self-esteem and self-regulation;
3) *the social mind and its codes*, i. e., norms and rules of social life ensuring conflict-free functioning and integration with society;
4) *the cultural mind and its codes*, i. e., recognized as its own moral systems created by nesting in the socio-cultural environment, as well as its own system of values and cultural signs and symbols.

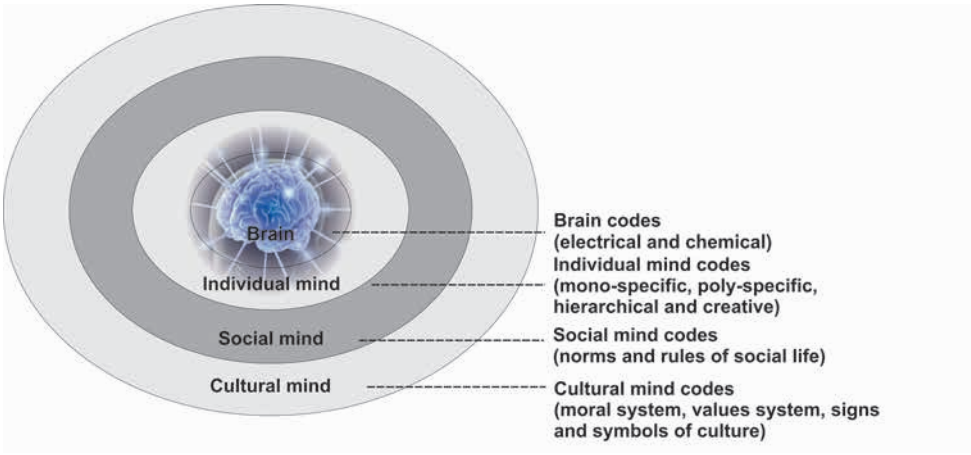

Figure 14. Hierarchy of brain, individual, social and cultural mind codes.
S o u r c e: Pąchalska, 2019

It should be emphasized that individual, social and cultural conditions of creativity are mainly associated with the three basic self-subsystems, that is:

1. *Awareness* that involves asking yourself about our identity: Who am I? In terms of civil law, this means sex, place of birth, origin, occupation, etc. This basic level of consciousness is often disturbed in the event of brain damage.
2. *Self-awareness*, i. e., awareness of myself and the state of my own mind, which is mainly associated with the questions: What am I? And how do other people see me? Answering these questions requires developed introspective skills, i. e., insight into yourself. It is also strongly associated with personality. In the cultural aspect, the way others see us is of particular importance, because this fact significantly affects our self-esteem. This process reflects the popular saying that "other people are our mirror".
3. *Meta-consciousness*, involving the questions: What values do I recognize? What is my place in the world? The answer to the question about recognized values determines our perception of ourselves, the world and our behavior. In turn, the answer to the question about our place in the world has a social and cultural aspect.

Recognized values are strongly embedded in culture and next to other cultural factors influence the shaping of our meta-consciousness. However, they can constitute a kind of self-limitation, which is manifested by various types of fundamentalism. This means that our meta-consciousness is also influenced by cultural conditions, among which should be mentioned a generational and procreative family, a group of friends, belonging to a social group, nationality, regionalism (cf. Bednarek, 2016), professed religion, etc. It should be emphasized that meta-consciousness is closely related to the development of the language system, called by Basil Bernstein (1990) the developed code. In Polish, the developed code concept corresponds to the term literary language (Kaczmarek, 2012).

Discussion

A person with brain damage may experience either underdevelopment, destabilization or loss of both self and loss of one or more of the brain codes discussed above, with particular emphasis on the individual, social and cultural mind (cf. Pąchalska, Kaczmarek, & Kropotov, 2020). This changes the creative abilities of this person in a way that is difficult to predict, related to the brain damage itself (Abraham, 2018), as well as its consequences and undertaken rehabilitation interventions (Pąchalska, 2019). She may lose her abilities or already find a new way of expressing herself in creation. Her creation, if it is created at all, can be assessed on a multi-dimensional basis as a work of varying degrees of revealing or not, new and original or not, useful or not, beautiful or not, communicative or not, colorful or not, disturbed (rotations, perseverations, side skipping) or not, embedded in culture or not. Many scholars propose different ways of assessing this work, which is discussed in more detail in the monographs by Pąchalska, Bednarek, et al. (2020).

In this context, it should be emphasized that the Lurian approach, which is successfully developed in process neuropsychology (Pąchalska et al., 2014; Pąchalska, Kaczmarek, & Kropotov, 2020) makes it possible to understand that the essence of the discovery is its "reading" by the discoverer. After the act initiating the discovery, it may be given in the form of further attempts to improve and direct it to a specific purpose.

After the act initiating the discovery, it may be given in the form of further attempts to improve and direct it to a specific purpose, often designated by the artist's individuality (see Pąchalska, 2019). It is not difficult to prove that the self system exerts an influence on the creative act, because the quality of creativity is associated with both neurobiological processes (Abraham, 2018), as well as cognitive, emotional and executive processes, as well as with the broadly understood social and cultural background (Pąchalska, 2019).

Conclusions

From the clinical neuroscience perspective, it is particularly important to use the creative possibilities of people, especially artists, with various brain injuries in their rehabilitation. However, something that is also important for the artist, selected works, especially the most characteristic and significant ones, are also recognized by critics. It also happens that they become part of the world's cultural heritage, such as the works of my patient Krystyna Habura, produced after a stroke in the process of art therapy, which are in the collections of several galleries in the world (see Pąchalska, 1999, 2003; Piechowski-Jozwiak & Bogusslavsky, 2013; Pąchalska & Góral-Półrola, 2020). The data presented confirm the significance of Luria's approach in the development of the neuropsychology of creativity. As it was also presented by his daughter (Luria E., 1991) the heritage of Luria's neuropsychological thought is significant and everlasting. To quote Horace: "Exegi monumentum aere perennius" [He built a work more durable than bronze]. His

scientific thought has inspired and continues to inspire many scholars in the world. In addition, this paper confirms also the importance of Luria's approach in the development of the neuropsychology of creativity.

Limitations of the study

The preset paper is limited to the description of one patient. And, therefore, some researchers might believe it risky to draw general conclusion. On the other hand, the careful and longitudinal observation of the patient and analysis of the problems encountered by him may give us an insight into brain mechanisms of the process in question (art creation in this case) as was so masterly performed by Luria.

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